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DISTANCE OF PLANTING RURAL NEW YORKER NO. 2 AND TRIUMPH POTATOES AS AFFECTING YIELD, HOLLOW HEART, GROWTH CRACKS, AND SECOND-GROWTH TUBERS

By W. C. Edmundson, *horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

For many years Rural New Yorker No. 2 has been the leading commercial variety of the Greeley, Colo., potato district. Although it is not especially a drought-resistant variety, it produces very satisfactory yields when the temperature is high if it is supplied with sufficient irrigation water. It is believed that this variety is partly resistant to some potato diseases. Furthermore, it is believed that insects often prefer other varieties for food. The Rural New Yorker No. 2 seldom if ever develops second-growth tubers even under adverse conditions; however, it is subject to growth cracks and hollow heart, and occasionally tubers of a very large size are produced under irrigation. A planting-distance experiment was conducted at the Colorado Potato Experiment Station[1] near Greeley to determine whether or not the spacings of sets in the field had a direct bearing on the size of the tubers or on the amount of growth crack and hollow heart produced.

During recent years the Triumph potato has become popular in the Greeley district as a late-crop variety. It was first tested for the late crop at the station in 1919, with such good results that growers were encouraged to plant a portion of their acreage with this variety. At present it ranks second among the late-crop varieties grown in the district and fits well into the program of the sugar-beet grower who wishes to grow potatoes. Experiments conducted at the station indicate that Triumph planted about June 10 for a late crop will ripen sufficiently early to permit the grower to harvest his potatoes during the latter part of September. Because of its increasing popularity, it was deemed advisable to study the effect of different spacings on yield, size, and type of tubers of this variety.

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[1] The work of the station has been conducted by the U. S. Department of Agriculture in cooperation with the Colorado State Board of Agriculture, and the Agricultural Experiment Station of Colorado.

REVIEW OF LITERATURE

In 1919 Wilson and Chittenden (*11*)[2] reported plantings made in rows 18, 24, 30, and 36 inches apart and seed spaced 9, 12, 15, and 18 inches apart in the rows of different widths. The best spacing for the variety used (Arran Chief) was 24 to 30 inches between rows with seed spaced 15 inches apart in the rows.

In 1920 Aicher (*1*) reported spacing studies which indicate that the largest percentage of marketable tubers, together with the greatest weight per tuber, were obtained from the greater distance between hills in the row. On alfalfa ground, plantings from 24 to 28 inches in the row gave the best yield. The most profitable yields of seed stock were obtained from planting seed 8 to 12 inches apart in the row, as close plantings reduced the size of the tubers.

In 1924 Brown (*2*) reported planting Irish Cobbler, Green Mountain, and Russet Rural potatoes in Connecticut in 3-foot rows with the hills ranging from 6 to 23 inches apart. In practically all tests the total yields were increased and the percentage of no. 1 potatoes decreased as the distance between hills was reduced. The net returns from the 9- and 12-inch spacings were larger than from other distances for the 3-year period. Since the net returns from the 9- and 12-inch spacings were not significantly different, the 12-inch spacing was recommended.

In 1925 Moore (*3*) of Michigan reported an experiment to determine what influence soil moisture, spacing distance, and date of planting had in producing hollow heart. In the early plantings the average percentage of hollow heart was 10.37 for the irrigated plots and 1.09 for the nonirrigated; in the late-planted plots the average was 3.81 percent for the irrigated plots and 0.85 for the nonirrigated. In the tests, seed spaced 36 by 18 inches gave an average increase in yield of 34.6 percent over the 36- by 36-inch spacing for the early planting and 18.1 percent for the late planting. The early plantings with seed spaced 36 by 36 inches produced 9.35 percent hollow-heart tubers compared with 2.65 percent for the 36- by 18-inch spacing. In the late planting, 36- by 36- inch spacing gave an average percentage of hollow heart of 3.39, whereas the 36- by 18-inch spacing produced 1.26 percent. The closer spacing produced larger yields of medium-sized tubers and less hollow heart.

In 1926 Moore (*4*) reported studies on rainfall, temperature, plant spacing, varietal susceptibility, soils, fertilizers, cultivation, etc., as factors contributing to hollow heart. For the reduction of hollow heart he recommended good cultural methods, the planting of a legume in the rotation, good seed, using large seed pieces, early planting, and shallow cultivations until plants are in blossom.

In 1926 Werner (*9*) reported studies made with Russet Rural potatoes grown with irrigation at the experiment station in Scotts Bluff County, Nebr. Hollow-heart tubers totaled 8.42 percent by count and 15.78 percent by weight of tubers weighing more than

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[2] Italic numbers in parentheses refer to Literature Cited, p. 18.

75 g. Hollow heart increased with the smaller number of stems per plant. This condition was much more prevalent in spindle tubers than in normal ones, and on a basis of calibrations made it occurred with elongated and thickened tubers. Growth cracking was also found to be a common characteristic of hollow heart. Its control was secured to a large extent by planting large-sized seed pieces, especially whole tubers.

In 1927 Moore (*5*) reported experiments conducted to determine the comparative effects of nitrogen, phosphoric acid, and potash, used separately or in combinations, as expressed in the development of hollow heart in Russet Rural potatoes. Potash applied alone delayed vine maturity and produced the maximum of hollow heart. The best quality potatoes were given by a combination of phosphorus and potash. The first hollow tubers were observed August 30. Hollow heart increased nearly 100 percent during the last 10 days of the growing season, the increase being attributed to the heavy rainfall during September. An increase in the number of stems per hill decreased the percentage of hollow heart and increased the number and total weight of tubers per hill.

In 1927 Werner (*10*) reported that hollow heart was found to occur most frequently when plants had relatively few stems, in growth-cracked tubers, in tubers of poor type, and in large tubers. It was also found that hollow heart increased in seriousness as growth cracking was more severe. Treating cut seed pieces with solutions of thiourea resulted in an increase in the number of stems and tubers and a decrease in the size of tubers and in hollow heart.

In 1928 Starring (*8*) of Montana reported tests conducted with hills spaced 14½, 11, and 7 inches, the average weight of seed pieces being 1½ ounces. Yield records were made on tubers under 2 ounces, those 2 to 8 ounces, those 8 to 12 ounces, and those over 12 ounces. A decidedly larger yield of 2- to 8-ounce tubers was secured with hills spaced 7 inches apart. The difference in yield varied from about 2,700 pounds to nearly 5,000 pounds per acre in favor of the 7-inch spacing; this distance also increased the yield of 8- to 12-ounce tubers. Spacing hills 7 inches apart reduced the yield of tubers larger than 12 ounces, thus eliminating many of the large, coarse tubers and much of the hollow heart.

In 1928 Moore and Wheeler (*6*) reported that hollow heart of the Russet Rural potato is likely to be serious in years when the rainfall during August is normal or above. Potash applied alone delayed the maturity of the vines and increased the percentage of hollow tubers. A complete fertilizer gave increased yields without increasing the percentage of potatoes showing hollow heart. Closer spacing of hills proved to be one of the most effective means of improving the market quality of potatoes by reducing the amount of hollow heart and increasing the yield of medium-sized potatoes. Planting larger seed pieces was also recommended to lessen the percentage of hollow-heart potatoes and for increasing the yield.

In 1929 Sprague and Evaul (*7*) of New Jersey reported that lessening the space between sets of the same size increased the yields. Size of the set and the planting rate had no appreciable effect on the percentage, by weight, of tubers weighing over 45 g each. Variations in yield were due primarily to changes in the number of tubers weighing over 45 g each, and not to their average individual weight.

OUTLINE OF EXPERIMENTS

The type of soil used in the studies reported in this bulletin was a clay loam, and a 4-year crop rotation of grain, alfalfa (2 years), and potatoes was maintained throughout the experiment. Light applications of barnyard manure were made each fall preceding the crowning of the alfalfa. The ground was left rough during the winter, and in the early spring it was plowed about 10 inches deep and a good seed bed was prepared. Each year the land selected for this experiment was well drained and uniform.

In 1928 and 1929 the plots were planted in triplicate and consisted of 2 rows each 242 feet long, planted 36 inches apart. In 1930 and 1931, 1-row plots 242 feet long were planted and were replicated four times. From 1928 to 1931, inclusive, plots were planted with seed pieces spaced 8, 10, 12, and 14 inches apart in the row. A strain of Rural New Yorker No. 2 developed at the station was used in the experiment.

In 1929, 1930, and 1931 plots were planted with Triumph, the seed pieces also being spaced 8, 10, 12, and 14 inches apart in the row. The seed of this variety was purchased each fall from growers in the northeastern part of Weld County, the same strain being used each year of the experiment.

Tubers weighing from 4 to 10 ounces were selected and cut into blocky pieces weighing from 1½ to 2 ounces, after which the seed was spread out in a thin layer on the dug-out floor until the cut surfaces were suberized. The weight of the seed pieces and the method of handling the seed planted in each plot were the same throughout the experiment. The plots of Rural New Yorker No. 2 were planted the latter part of May; those of Triumph were planted between June 5 and June 10. Tests made at the station indicated that the Rural New Yorker No. 2 generally produced best when planted the last of May or the first of June, whereas Triumph planted as late as June 10 generally produced the largest yields.

All seed was planted by hand. The spacings were made accurate by a special planting chain made by connecting small metal rings with wire, the seed pieces being placed opposite each ring in the wire. A freshly dug furrow about 4 inches deep was opened by a specially made shovel attached to a potato planter and the seed pieces were placed in the bottom of it. The disks attached to the rear of the potato planter for covering seed were disconnected so that no dirt would be forced into the furrow. As soon as a row was planted the seed was covered by using a potato cultivator with wide shovels adjusted to carry sufficient soil to cover the seed to a depth of 6 or 7 inches and form a wide ridge.

The precipitation at the station during the growing seasons of the years covered by the experiment is shown in table 1, and the dates of irrigation are given in table 2.

TABLE 1.—*Precipitation at the Colorado Potato Experiment Station, Greeley, during the growing seasons, 1928 to 1931, inclusive*

1928		1929		1930		1931	
Dates of rainfall	Precipitation	Dates of rainfall	Precipitation	Dates of rainfall	Precipitation	Dates of rainfall	Precipitation
	Inches		*Inches*		*Inches*		*Inches*
May 3	0.67	May 5	0.03	May 4	0.09	May 2	0.55
May 4	.08	May 6	.48	May 5	.04	May 17	.24
May 11	.48	May 11	.53	May 6	.11	May 28	.32
May 12	.05	May 18	.12	May 8	.15	May 29	.67
May 14	.15	June 1	.26	May 9	.31	May 30	.12
May 15	.28	June 7	.27	May 16	.43	June 5	.44
May 17	.05	June 13	.69	May 18	.86	June 11	.14
May 18	.05	July 6	.15	May 19	.16	June 21	.05
May 19	.41	July 10	.05	May 23	.30	July 1	.17
May 20	.05	July 19	.10	June 1	.16	July 31	.17
May 21	.05	July 23	.11	June 22	.15	Aug. 1	.18
May 24	.16	Aug. 3	.82	July 13	.43	Aug. 2	.22
May 25	.12	Aug. 5	.52	July 14	.05	Aug. 9	.27
May 28	.12	Aug. 7	.05	July 21	.48	Aug. 16	.23
June 2	.13	Aug. 20	.21	Aug. 4	.12	Aug. 19	.04
June 4	1.55	Sept. 2	.41	Aug. 8	.56	Aug. 23	.10
June 5	.68	Sept. 3	.31	Aug. 10	.43	Sept. 2	.05
June 12	.08	Sept. 5	.81	Aug. 12	.97		
June 17	.23	Sept. 6	.08	Aug. 13	.23		
June 18	.64	Sept. 7	.12	Aug. 14	1.24		
June 29	1.43	Sept. 8	.08	Aug. 15	.90		
June 30	2.06	Sept. 30	.29	Aug. 29	.45		
July 7	.43			Sept. 9	.15		
July 17	.40			Sept. 11	.25		
July 19	.38			Sept. 25	.25		
July 20	.22						
July 21	.42						
July 22	.44						
July 29	.55						
Aug. 3	.70						
Aug. 17	.21						
Aug. 25	.63						
Sept. 3	.07						
Total	13.97	Total	6.49	Total	9.27	Total	3.96

TABLE 2.—*Dates of irrigations for potato varieties grown at the Colorado Potato Experiment Station, 1928 to 1931, inclusive*

Rural New Yorker No. 2				Triumph		
1928	1929	1930	1931	1929	1930	1931
July 13	July 2	July 5	July 6	June 29	July 5	July 6
Aug. 2	July 16	July 21	July 16	July 13	July 21	July 17
Aug. 13	July 23	July 31	July 29	July 22	July 31	July 29
Aug. 21	Aug. 2	Aug. 6	Aug. 10	Aug. 2	Aug. 6	Aug. 11
Aug. 28	Aug. 14	Aug. 21	Aug. 19	Aug. 15	Aug. 21	Aug. 20
Sept. 4	Aug. 20	Aug. 27	Aug. 25	Aug. 21	Aug. 27	Aug. 26
	Aug. 27	Sept. 4	Sept. 3	Aug. 28	Sept. 4	Sept. 4

The first irrigation water was applied as soon as the plants seemed to require moisture to make a continuous growth. Dwarfing of the plants, wilting of the leaves, and color of the foliage were used as indices to determine the amount of moisture in the soil available to the plants. Plants supplied with proper amounts of moisture for good growth have foliage of normal color for the variety. As the supply of moisture diminishes in the soil, the foliage assumes a darker green color, whereas an oversupply is indicated by light-green foliage. After the first irrigation the soil was kept moist by frequent light irrigations until about the first week in September, when the operations were terminated. All plots were irrigated by running water on both sides of the rows, and the flow of water was stopped when the moisture had seeped through sufficiently to moisten the soil in the row immediately under the hills. The plots were cultivated to kill weeds and loosen the soil after each irrigation until the size of the vines interfered with cultivation.

All plots were harvested with a potato digger, care being taken not to cut any of the tubers and that none were lost. The tubers were placed in labeled sacks and taken to the potato storage cellar, where they were graded by hand into the following groups: (1) Tubers weighing less than 3 ounces (85.05 g); (2) smooth tubers, 3 to 12 ounces (340.20 g); (3) those weighing 12 to 16 ounces (453.6 g), and (4) those 16 or more ounces. Growth-cracked tubers were also placed in the different weight groupings to determine the number and yield from each distance of planting. After the data were recorded, all tubers weighing over 12 ounces, including the growth-cracked tubers or any that might possibly be hollow, were cut to determine the amount of hollow heart represented in the different groups. The yield of second-growth tubers was also recorded.

DISTANCE OF PLANTING AS AFFECTING YIELDS OF RURAL NEW YORKER NO. 2

The yields of Rural New Yorker No. 2 from plantings at different distances in the rows for the four seasons are shown in table 3.

In 1928 the plots were planted May 26. The rainfall in June and July was heavy (table 1), and but one irrigation was applied during July (table 2). The plants were severely injured by hail on June 29 and July 19 and 29, each storm stripping the plants of part of their leaves and wounding or breaking many of the stems. The broken stems healed sufficiently to transport plant food, and fair yields were produced even under such adverse conditions. The plots received six irrigations in that year. A killing frost did not occur until October 17, but the plants had matured sufficiently to permit harvesting the plots on October 9. The data for 1928 in table 3 show that there was very little difference in the yield of tubers weighing between 3 and 12 ounces from plantings made at 8, 10, or 12 inches. Plots planted with seed pieces spaced 14 inches apart in the row produced a much smaller yield of tubers between 3 and 12 ounces, but a larger yield of tubers weighing 12 or more ounces.

Table 3.—*Yields of tubers of different sizes of Rural New Yorker No. 2 potatoes from seed pieces planted at different distances apart in rows at Greeley, Colo., 1928–31*

Distance of planting in row	Year	Hills	Yield of tubers per plot					Estimated acre yield						
			Tubers under 3 ounces	Tubers 3 to 12 ounces	Tubers 12 to 16 ounces	Tubers 16 ounces and above	Total tubers above 3 ounces	Tubers under 3 ounces	Tubers 3 to 12 ounces	Tubers 12 to 16 ounces	Tubers 16 ounces and above	Total yield of tubers 3 ounces and above	Total	Total less seed used
Inches		*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
8	1928	2, 154	1, 437	3, 817	91	18	3, 926	32. 23	247. 42	13. 12	3. 99	264. 53	296. 76	--------
	1929	1, 846	2, 174	3, 216	48	11	3, 275	41. 50	184. 10	6. 42	2. 15	192. 67	234. 17	--------
	1930	1, 791	2, 565	5, 333	66	7	5, 406	64. 30	403. 00	10. 35	1. 57	414. 92	479. 22	--------
	1931	1, 884	1, 861	5, 513	128	46	5, 687	48. 50	433. 55	21. 90	11. 15	466. 60	515. 10	--------
	Average	1, 918. 75	2, 009. 25	4, 469. 75	83. 25	20. 50	4, 573. 50	46. 63	317. 02	12. 95	4. 71	334. 68	381. 31	341. 57
10	1928	1, 709	1, 189	3, 763	142	33	3, 938	25. 58	253. 92	20. 50	7. 64	282. 06	307. 64	--------
	1929	1, 437	2, 158	2, 918	74	19	3, 011	40. 50	177. 83	10. 62	4. 39	192. 84	233. 34	--------
	1930	1, 431	2, 083	4, 893	102	26	5, 021	49. 90	399. 50	18. 32	5. 20	423. 02	472. 92	--------
	1931	1, 415	1, 627	5, 176	164	43	5, 383	41. 20	406. 35	28. 87	10. 40	445. 62	486. 82	--------
	Average	1, 498. 00	1, 764. 25	4, 187. 50	120. 50	30. 25	4, 338. 25	39. 29	309. 40	19. 58	6. 91	335. 89	375. 18	343. 48
12	1928	1, 430	972	3, 527	155	58	3, 740	20. 50	249. 25	22. 00	12. 85	284. 10	304. 60	--------
	1929	1, 166	1, 503	2, 262	81	36	2, 379	29. 42	165. 17	11. 50	7. 58	184. 25	213. 67	--------
	1930	1, 187	1, 914	4, 185	122	39	4, 346	42. 80	382. 10	21. 72	7. 80	411. 62	454. 42	--------
	1931	1, 190	1, 593	5, 006	178	59	5, 243	40. 00	407. 60	30. 17	14. 25	452. 02	492. 02	--------
	Average	1, 243. 25	1, 495. 50	3, 745. 00	134. 00	48. 00	3, 927. 00	33. 18	301. 03	21. 35	10. 62	333. 00	366. 18	339. 69
14	1928	1, 220	983	2, 955	178	57	3, 190	22. 50	223. 58	25. 75	13. 13	262. 46	284. 96	--------
	1929	928	1, 259	2, 008	97	48	2, 153	23. 83	127. 83	16. 17	10. 71	154. 71	178. 54	--------
	1930	1, 011	1, 474	3, 928	177	59	4, 164	25. 80	376. 60	31. 97	11. 80	420. 37	446. 17	--------
	1931	1, 024	1, 176	4, 793	203	84	5, 080	31. 10	392. 35	34. 98	19. 80	447. 13	478. 23	--------
	Average	1, 045. 75	1, 223. 00	3, 421. 00	163. 75	62. 00	3, 646. 75	25. 81	280. 09	27. 22	13. 86	321. 17	346. 98	324. 28

In 1929 the plots of Rural New Yorker No. 2 were planted May 27. The rainfall was rather light during June and July and there was a fair amount during August. The first week in September was cold and rainy, and on September 8 the temperature dropped to 28° F., injuring the potato vines so that there was practically no tuber growth after that date. The early frost accounted for the low yield. It will be noted, however, that the yield of tubers between 3 and 12 ounces decreased with the greater distance of planting, whereas the yield of the larger tubers was increased.

The growing seasons of 1930 and 1931 were somewhat similar. Plots were planted May 28, 1930, and May 27, 1931. In these 2 years the initial irrigation was given about the same time, and the last one was applied September 4, 1930, and September 3, 1931 (table 2). A killing frost occurred September 25, 1930, and October 12, 1931. The yield of tubers weighing between 3 and 12 ounces was increased by the closer spacing of seed in the row, whereas the yield of tubers between 12 and 16 ounces and those above 16 ounces were, with one exception, increased by planting the seed farther apart in the row (table 3).

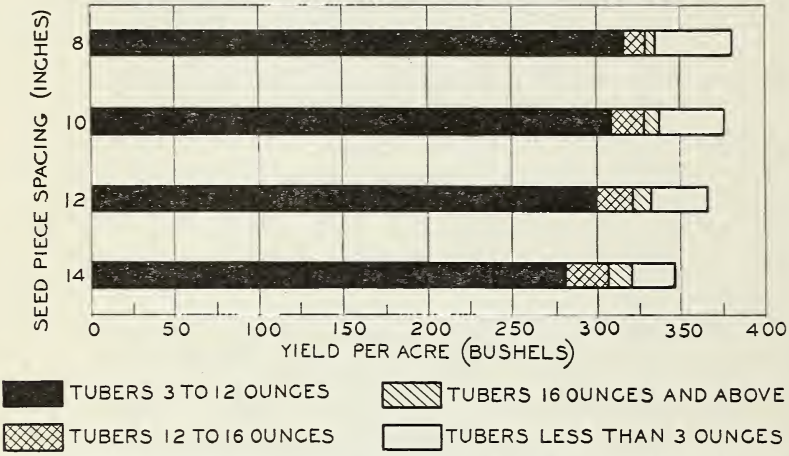

FIGURE 1.—Four-years' average yields of Rural New Yorker No. 2 potatoes, in bushels per acre, of tubers of different sizes resulting from seed pieces planted at different distances apart in the rows.

As shown in table 3 and figure 1 the 4-year average yield of tubers less than 3 ounces in weight and from 3 to 12 ounces in size was increased with the closer spacings, whereas seed spaced 14 inches apart in the row produced a lower average yield. However, the average yield of tubers weighing 12 to 16 ounces and tubers of 16 ounces and above increased as the distance between hills was increased. The total yield of tubers weighing 3 ounces and above was practically the same from the seed planted 8, 10, or 12 inches apart, whereas the plots planted with seed spaced 14 inches apart did not yield so heavily. Deducting the amount of seed used to plant the different plots, there is very little difference in the net yield from the seed spaced 8, 10, or 12 inches apart in the row, but the net yield of the 14-inch spacing was somewhat lower.

DISTANCE OF PLANTING AS AFFECTING HOLLOW HEART AND GROWTH CRACKS IN RURAL NEW YORKER NO. 2

Throughout the experiment no second-growth tubers were produced with the Rural New Yorker No. 2, and it is believed that this variety is not subject to second-growth development even under adverse growing conditions. It is, however, subject to hollow heart and growth cracks, but in 1928 and 1929 neither of these conditions developed. In 1928 three hailstorms occurred, each doing considerable damage to plants, stripping the leaves and wounding or breaking the stems. The growth of the tubers was slow, which possibly accounted for the fact that no hollow-heart or growth-cracked tubers developed. The growing season of 1929 was about normal until September. Rain began falling September 2, and, with the exception of 1 day, rain fell each day until September 8. On the night of September 8 the temperature dropped to 28° F., killing about half of the potato foliage. On September 15 the temperature again dropped to 28°, killing all foliage that survived the first frost. No hollow heart or growth cracking occurred in that year, and this fact is believed to be due to the early frost.

In 1930 and 1931, however, hollow heart and growth cracks appeared. Table 4 gives the number of smooth, growth-cracked, and hollow-heart tubers and the estimated yields, in bushels per acre, arranged in size groups. The data show that the yield of smooth tubers weighing between 3 and 12 ounces increased with the closer planting of seed, and that the proportion of growth-cracked tubers increased with the greater spacings between plants (fig. 2). With but one exception, the yield of growth-cracked tubers of the larger sizes increased slightly as the distance between the plants was increased.

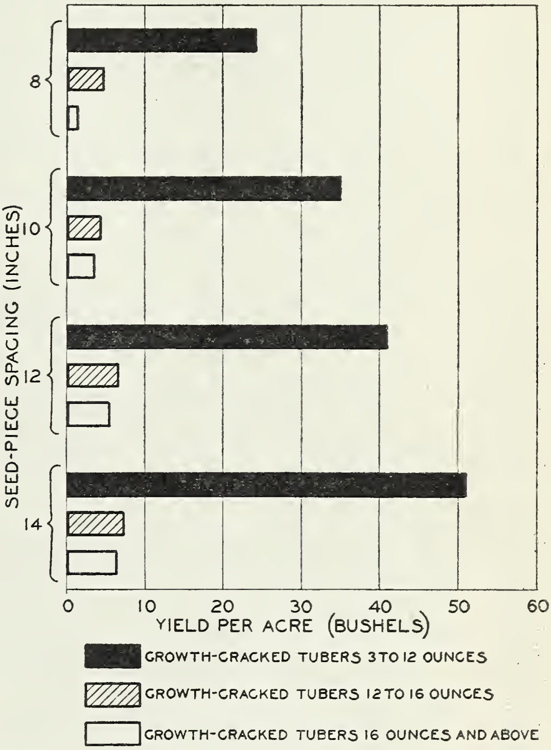

FIGURE 2.—Two-years' average yields of Rural New Yorker No. 2 potatoes, in bushels per acre, of growth-cracked tubers of different sizes resulting from seed pieces planted at different distances apart in the rows: *A*, Tubers 3 to 12 ounces; *B*, tubers 12 to 16 ounces; *C*, tubers 16 or more ounces.

TABLE 4.—*Yields of smooth, growth-cracked, and hollow-heart tubers of different sizes of Rural New Yorker No. 2 potatoes from seed pieces planted at different distances apart in rows at Greeley, Colo., 1930 and 1931*

YIELD OF TUBERS PER PLOT

Distance of planting in row	Year	Hills	Smooth tubers					Growth-cracked tubers				Hollow-heart tubers			
			Under 3 ounces	3 to 12 ounces	12 to 16 ounces	16 ounces and above	3 ounces and above	3 to 12 ounces	12 to 16 ounces	16 ounces and above	3 ounces and above	3 to 12 ounces	12 to 16 ounces	16 ounces and above	3 ounces and above
Inches		*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
8	1930	1,791	2,565	5,014	46	5	5,065	319	20	2	341	14	13	2	29
	1931	1,884	1,861	5,253	91	35	5,379	260	37	11	308	5	4	13	22
	Average	1,837.5	2,213	5,133.5	68.5	20	5,222	289.5	28.5	6.5	324.5	9.5	8.5	7.5	25.5
10	1930	1,431	2,083	4,400	76	16	4,492	493	26	10	529	28	20	14	62
	1931	1,415	1,627	4,915	140	27	5,082	261	24	16	301	1	7	13	21
	Average	1,423.0	1,855.0	4,657.5	108.0	21.5	4,787.0	377.0	25.0	13.0	415.0	14.5	13.5	13.5	41.5
12	1930	1,187	1,914	3,656	89	25	3,770	528	33	14	575	33	38	17	88
	1931	1,190	1,593	4,642	139	29	4,810	364	39	30	433	2	7	18	27
	Average	1,188.5	1,753.5	4,149.0	114.0	27.0	4,290.0	446.0	36.0	22.0	504.0	17.5	22.5	17.5	57.5
14	1930	1,011	1,474	3,266	128	39	3,433	662	49	20	731	54	55	28	137
	1931	1,024	1,176	4,431	166	51	4,648	362	37	33	432	11	10	25	46
	Average	1,017.5	1,325	3,848.5	147.0	45.0	4,040.5	512.0	43.0	26.5	581.5	32.5	32.5	26.5	91.5

ESTIMATED ACRE YIELD

			Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
8	1930		64.30	379.20	7.25	1.17	387.62	23.80	3.30	0.47	27.57	1.60	2.13	0.47	4.20
	1931		48.50	408.60	15.60	8.40	432.60	24.95	6.30	2.75	34.00	.55	.66	3.30	4.51
	Average		56.40	393.90	11.43	4.79	410.12	24.38	4.80	1.61	30.79	1.08	1.40	1.89	4.37
10	1930		49.90	351.80	13.57	3.85	369.22	47.70	4.75	2.32	54.77	3.20	3.35	3.20	9.75
	1931		41.20	382.60	24.72	6.40	413.72	23.75	4.15	4.00	31.90	.10	1.20	3.25	4.55
	Average		45.55	367.20	19.15	5.13	391.48	35.73	4.45	3.16	43.34	1.65	2.28	3.23	7.16
12	1930		42.80	339.10	16.07	5.27	360.44	49.00	5.65	3.39	58.04	4.17	6.62	4.10	14.89
	1931		40.00	373.40	23.55	7.22	404.17	34.20	6.62	7.05	47.87	.22	1.51	4.60	6.33
	Average		41.40	356.25	19.81	6.25	382.31	41.60	6.14	5.22	52.96	2.20	4.07	4.35	10.62
14	1930		25.80	308.80	23.47	7.80	340.07	67.80	8.50	5.00	81.30	6.97	9.60	6.95	23.52
	1931		31.00	355.30	28.85	11.90	396.05	37.05	6.13	7.90	51.08	1.27	1.68	6.40	9.35
	Average		28.40	332.05	26.16	9.85	368.06	52.43	7.32	6.45	66.20	4.12	5.64	6.68	16.44

In years when growth cracks occurred, the cracking was not confined to the larger tubers (figs. 2 and 3). It appears that too rapid growth of the tubers generally results in growth cracks and hollow heart. As heretofore stated, no growth cracks or hollow heart appeared in 1928 or 1929, probably because of the hail injury sustained in 1928 and to the early frost of 1929. However, there have been years when yields were larger than in 1928 and 1929, when vines were not injured during the summer or killed by an early frost, and when little or no growth cracks or hollow heart developed. Tubers with growth cracks are quite commonly found to be hollow (figs. 4 and 5). Frequently tubers making a rapid growth develop an abnormal thickness in the middle of the tuber or at the apical end (fig. 6). This type of growth usually occurs during years when growth cracks appear and generally results in the development of hollow heart.

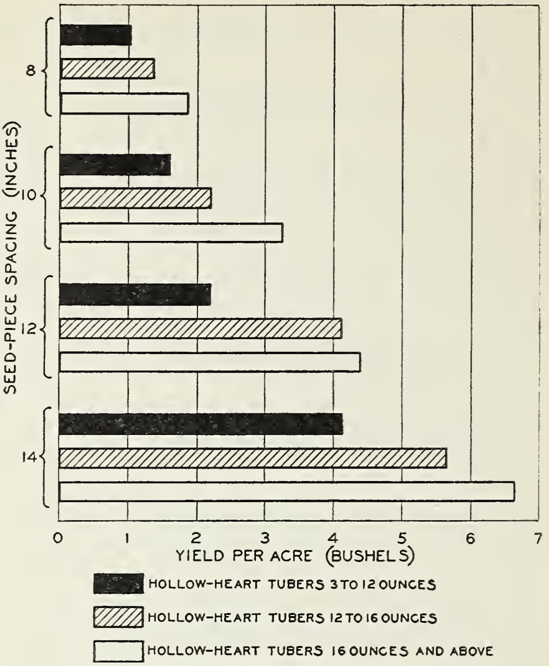

FIGURE 3.—Two-years' average yields of Rural New Yorker No. 2 potatoes, in bushels per acre, of hollow-heart tubers of different sizes resulting from seed pieces planted at different distances apart in the rows. *A*, Tubers 3 to 12 ounces; *B*, tubers 12 to 16 ounces; *C*, tubers 16 or more ounces.

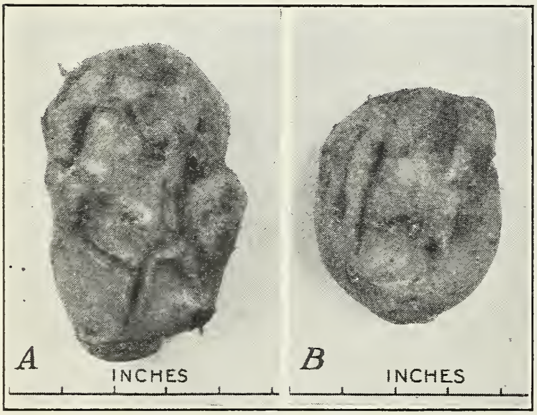

FIGURE 4.—Rural New Yorker No. 2 potato tubers showing growth cracks: *A*, 16 ounces; *B*, 10 ounces. Both tubers were hollow.

DISTANCE OF PLANTING AS AFFECTING YIELDS OF TRIUMPH

The yields of Triumph potatoes from planting at different distances in the rows for the three seasons are shown in table 5.

In 1929 the plots were planted June 5. The rainfall was light during the early part of the growing season, and the weather was cold and rainy the first part of September (table 1). Frost occurred September 8, and the plots were harvested September 19. Notwithstanding the fact that the vines were killed by early frost, good yields were secured. The plots received 7 irrigations in 1929, the first on June 29, 2 in July, and 4 in August (table 2).

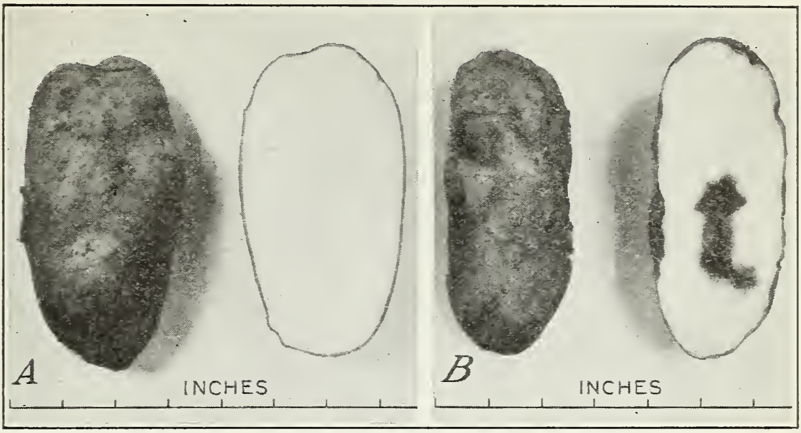

FIGURE 5.—Rural New Yorker No. 2 potato tubers: *A*, 18 ounces, smooth, not hollow; *B*, 16 ounces, growth cracked, with typical hollow heart.

In 1930 the plots were planted June 5 and the first irrigation water was applied July 5. There were 3 irrigations in July and 3 in August, the last being given on September 4. The vines ripened before a killing frost, and the plots were harvested September 23. The Triumphs did not yield as well in 1930 as in other years, resulting in a larger production of tubers weighing less than 3 ounces (table 5).

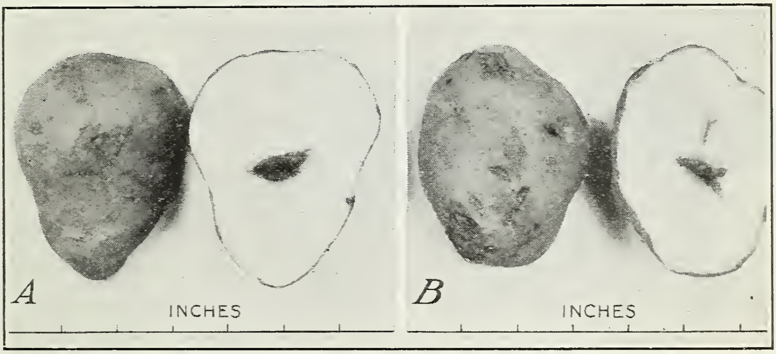

FIGURE 6.—Rural New Yorker No. 2 potato tubers showing thickening at apical end (*A*) and at middle (*B*) Both types are frequently hollow.

TABLE 5.—*Comparison of number of tubers and relative yields of smooth and second-growth tubers of different sizes of the Triumph variety resulting from planting seed pieces 8, 10, 12, and 14 inches apart in the rows at Greeley, Colo., 1929–31*

Distance of planting	Year	Hills	Yield of tubers per plot								Estimated acre yields									
			Tubers under 3 ounces	Smooth tubers			Rough (second-growth) tubers			Tubers 3 ounces and above	Tubers under 3 ounces	Smooth tubers			Rough (second-growth) tubers			Tubers 3 ounces and above	Total yield	Total yield less seed
				3 to 12 ounces	12 to 16 ounces	16 ounces and above	3 to 12 ounces	12 to 16 ounces	16 ounces and above			3 to 12 ounces	12 to 16 ounces	16 ounces and above	3 to 12 ounces	12 to 16 ounces	16 ounces and above			
Inches		*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
8	1929	1,901	2,197	4,767	25	0	69	65	22	4,948	41.25	333.86	3.61	0.00	6.47	9.52	4.56	358.02	399.27	-------
	1930	1,930	3,760	4,306	5	0	27	10	1	4,349	79.60	306.44	.74	.00	3.46	1.76	.25	312.65	392.25	-------
	1931	1,744	2,802	5,904	31	0	37	21	12	6,005	55.20	392.65	4.69	.00	4.65	3.51	2.95	408.45	463.65	-------
	Average	1,858.33	2,919.67	4,992.33	20.33	0	44.33	32.00	11.67	5,100.66	58.68	344.32	3.01	.00	4.86	4.93	2.59	359.71	418.39	378.69
10	1929	1,625	1,804	4,547	62	0	73	62	24	4,768	32.00	321.89	10.14	.00	6.90	8.83	5.58	353.34	385.34	-------
	1930	1,417	2,684	4,329	4	0	38	12	1	4,384	55.40	321.31	.72	.00	4.19	2.00	.22	328.44	383.84	-------
	1931	1,421	2,598	5,337	25	0	35	24	8	5,429	52.80	386.63	3.73	.00	4.17	4.07	2.25	400.85	453.65	-------
	Average	1,487.67	2,362.00	4,737.67	30.33	0	48.67	32.67	11.00	4,860.34	46.73	343.28	4.86	.00	5.09	4.97	2.68	360.88	407.61	375.91
12	1929	1,370	1,744	4,467	90	5	73	75	37	4,747	34.25	307.20	13.76	1.67	5.68	10.32	9.08	347.71	381.96	-------
	1930	1,179	2,710	4,187	8	0	56	20	3	4,274	61.00	306.90	1.41	.00	6.00	3.44	.72	318.47	379.47	-------
	1931	1,169	2,464	5,225	28	0	50	36	15	5,354	49.80	388.25	5.00	.00	5.55	5.50	3.90	408.20	458.00	-------
	Average	1,239.33	2,306.00	4,626.33	42.00	1.67	59.67	43.67	18.33	4,791.67	48.35	334.12	6.72	.56	5.74	6.42	4.57	358.13	406.48	379.97
14	1929	1,168	1,394	4,278	83	4	74	76	36	4,551	19.17	296.32	12.74	1.51	5.55	10.97	8.45	335.54	354.71	-------
	1930	1,006	2,321	4,178	25	0	46	24	7	4,280	49.50	311.80	4.14	.00	5.30	4.31	1.70	327.25	376.75	-------
	1931	973	2,448	4,934	26	0	50	25	14	5,049	46.70	368.55	3.95	.00	6.25	4.20	4.30	387.25	433.95	-------
	Average	1,049.00	2,054.33	4,463.33	44.67	1.33	56.67	41.67	19.00	4,626.67	38.46	325.56	6.94	.50	5.70	6.49	4.82	350.01	388.47	365.77

In 1931 the Triumph plots were planted July 10 and the initial irrigation was on July 6. The plots received 3 irrigations in July, 3 in August, and the last one September 4. A killing frost did not occur until October 12; however, the Triumphs ripened early and were harvested September 24. The growing season of this year was hot and dry, with very little rainfall (table 1); however, with seven light irrigations, very satisfactory yields were secured. Seed pieces spaced 8, 10, and 12 inches apart produced similar yields; those spaced 14 inches apart gave a slightly smaller yield. There was very little difference in yield of culls or tubers weighing less than 3 ounces resulting from the different spacings of seed in that year.

For the 3-year period, table 5 shows that the yield per acre of tubers weighing less than 3 ounces increased with the closer spacings of seed in the row. Similar yields of tubers weighing 3 or more ounces were obtained from seed spaced 8, 10, and 12 inches apart; the 14-inch spacings produced a slightly smaller yield. In addition, table 5 gives a comparison of relative total yields resulting from the different spacings of seed and also a comparison of the net or total yields less the amount of seed used.

DISTANCE OF PLANTING AS AFFECTING SECOND-GROWTH TUBERS OF TRIUMPH

No hollow heart developed in any of the tubers of the Triumph variety during this experiment; furthermore, the amount of growth-cracked tubers was so small it was deemed of no importance. This variety does, however, produce rough or second growth tubers, possibly seasonal conditions being largely responsible for the amount developed. There have been seasons when no rough or second growth tubers were developed in plots grown at the Greeley station.

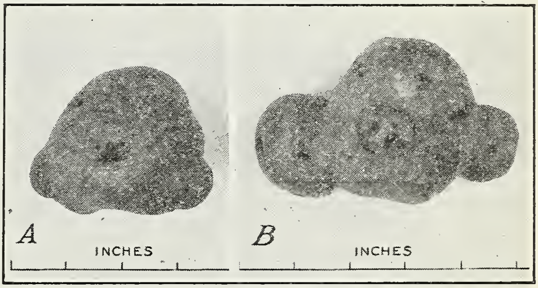

FIGURE 7.—Rough or second-growth Triumph potato tubers.

During the 3 years that these studies were conducted, rough tubers were produced in each plot. The number of smooth and rough tubers of the different sizes was recorded, and the results, together with the estimated acre yields, are given in table 5. Most of the rough-tuber development appeared to be caused by protruding eyes (fig. 7), although in many instances second-growth tubers that reached the size of the tuber to which they were attached were noted.

In 1929 the plots planted with seed pieces spaced 8 inches apart in the row produced 20.55 bushels of rough or second-growth tubers per acre; 10-inch spacings produced 21.31 bushels, and the 12-inch, 25.08 bushels; the 14-inch spacings produced a slightly smaller yield, or 24.97 bushels per acre.

Few rough tubers developed in 1930. The 8-inch spacings produced 5.47 bushels per acre, the 10-inch 6.41 bushels, the 12-inch 10.16 bushels, and the 14-inch 11.31 bushels. Although the difference is not large, there was a small increase in the yield of rough tubers with the increased distance between hills.

Although 1931 was a hot, dry year, all plots produced some rough tubers, but the yield varied little with the different distances of planting. The 8-inch spacings produced 11.11 bushels per acre, the 10-inch 10.49 bushels, the 12-inch 14.95 bushels, and the 14-inch 14.75 bushels.

A very large percentage of the Triumph tubers weighed less than 12 ounces (fig. 8), probably because this variety sets a large number of tubers per hill. Of the tubers weighing 12 to 16 ounces, 52 percent were rough; all those weighing 16 ounces or more were rough except 9; however, a very small percentage of those weighing between 3 and 12 ounces were rough. Comparing the total yield of rough tubers, it will be noted that seed planted 8 inches apart in the row produced an average of 12.38 bushels per acre for the 3 years, the 10-inch spacings produced 12.74 bushels, the 12-inch 16.73 bushels, and the 14-inch 17.01 bushels.

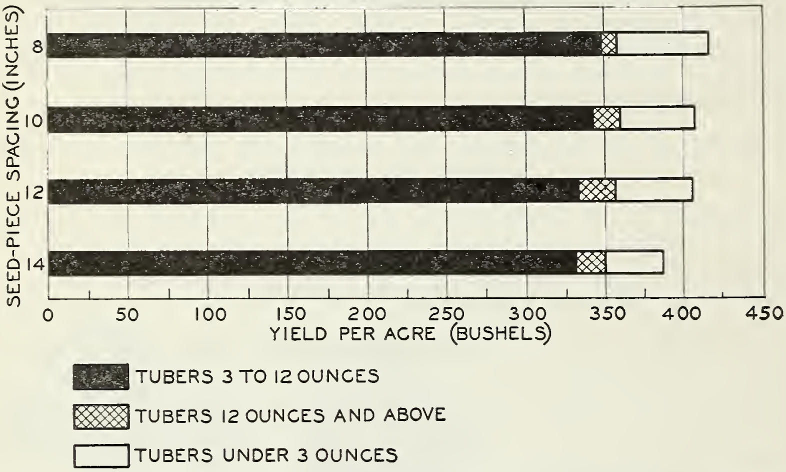

FIGURE 8.—Three-years' average yields of Triumph potatoes, in bushels per acre, of tubers of different sizes resulting from seed pieces planted at different distances apart in the rows.

DISCUSSION

Tests with Rural New Yorker No. 2 showed that seasonal conditions have a deciding influence on yields, development of hollow heart, and growth cracking of tubers; however, even under adverse growing conditions this variety does not produce second-growth tubers. Experiments conducted at Greeley, Colo., and elsewhere indicate that this variety is particularly susceptible to hollow heart and growth cracking, although there have been many seasons in which no hollow heart or growth cracking occurred.

During the time these studies were being conducted, practically all hollow heart and growth cracking of tubers occurred during September. It is quite probable that missing hills are partly responsible for the production of the extra large tubers and hollow heart. Growers are often careless with the handling of seed after cutting and frequently in this section seed becomes infected with fusarium wilt after cutting, resulting in poor stands.

The distance apart that seed pieces should be spaced in the row depends on soil fertility, the amount of moisture available for plant growth, size and condition of the seed, and whether or not cut seed is used. It is believed that each grower should learn from experience the proper distance for planting on his farm. If larger tubers than desired by the trade are produced, closer spacing will reduce the size by increasing the number of smaller tubers with little difference in total yield. At the Greeley station, seed of Rural New Yorker No. 2 spaced 10 to 12 inches apart has proved very satisfactory.

Triumph does not appear to be susceptible to hollow heart, nor does growth cracking of tubers seem to be a serious problem; but it does develop second-growth or rough tubers when grown under irrigation. There have been seasons at the station, however, when no second-growth tubers were developed in any Triumph plot. It appears that the development of such tubers is caused partly by seasonal conditions and partly by irrigation water. Spacing seed 8, 10, 12, and 14 inches apart in the row has had little effect on the development of second-growth tubers (fig. 9). The production of large, overgrown tubers has not been a serious problem with this variety, probably because of the relatively large number of tubers produced per hill. It is believed that where conditions are similar to those at the experiment station, and growers follow a similar crop rotation, good results will be secured by spacing the seed 12 inches apart in the rows.

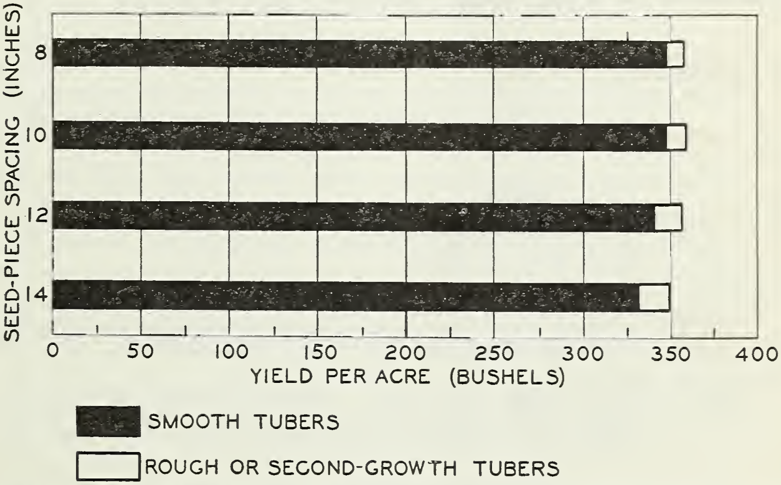

FIGURE 9.—Three-years' average yields of Triumph potatoes, in bushels per acre, of smooth and rough or second-growth tubers above 3 ounces in size resulting from seed pieces planted at different distances apart in the rows.

SUMMARY

Rural New Yorker No. 2 potato seed spaced 8, 10, 12, and 14 inches, respectively, in rows 36 inches apart gave an increased yield of tubers under 3 ounces in size as the distance between hills was diminished.

The yield of tubers weighing 3 to 12 ounces was likewise increased with the closer spacing. However, yields of 12- to 16-ounce tubers and of tubers of 16 ounces and above were increased as the distance between hills was increased.

The total net yield of tubers weighing 3 ounces and above was practically the same from seed planted 8, 10, and 12 inches apart; seed pieces spaced 14 inches apart did not yield as well for the 4-year period.

The Rural New Yorker No. 2 developed hollow heart and growth cracks in 2 years of the 4-year experiment. Hollow heart and growth cracking increased as the distance between hills was increased.

Seed of the Triumph variety spaced 8, 10, and 12 inches apart produced similar yields; somewhat lower yield was obtained from seed spaced at 14 inches. The yield of Triumph tubers weighing 12 ounces and above was very small. No hollow heart occurred, and the amount of growth cracking was of no importance.

Spacing of Triumph seed had little effect on the yield of second-growth tubers, although there was a slight increase in yield as the distance between hills was increased.

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